Economics of Adopting Weeding Robots

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i-FARM

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The problem: Herbicide-resistant weeds

Genetically modified herbicide-resistant crops have been adopted on more than 93% of the planted acres under row crops in the US

- This has led to the exclusive reliance on herbicides for weed control

The problem: Herbicide-resistant weeds

The over-use of herbicides on herbicide-tolerant crops has led to a rapid increase in herbicide-resistant weeds since they were first reported in 1970

The problem: Herbicide-resistant weeds

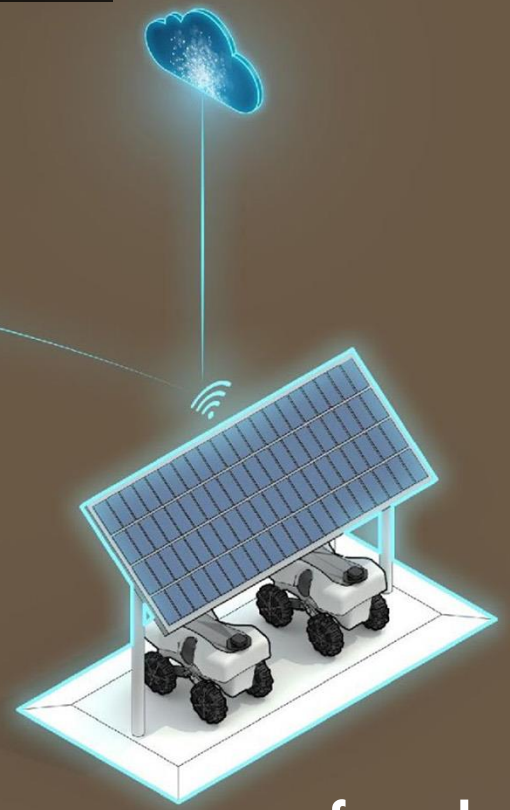
Growing weed resistance is reducing the effectiveness of glyphosate and adversely impacting harvestable yields in corn, cotton, and soybeans in the US.

- Crop losses due to herbicide-resistant weeds are projected to reach $100 billion per year if the efficacy of chemical control is lost to resistance

The potential solution

Robotic weed control has emerged as an alternative technology for mechanically removing weeds, using artificial intelligence for navigation and automation.

Weeding robots for mechanical weeding provide a low labor intensity, high-efficiency, environmentally friendly solution.

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Factors to consider when adopting weeding robots:

Technology attributes

- Level of autonomy
- Maintenance costs
- Speed at which they travel
- Efficacy with which they eliminate weeds

Factors to consider when adopting weeding robots:

Economic factors

- Crop prices
- Herbicide costs
- Robot prices
- Labor costs

Factors to consider when adopting weeding robots:

Biophysical conditions and their economic consequences

- Weed density and level of resistance
- Seed bank: How do weed management decisions in one year affect not only same-year profits but also the seed bank and, therefore, future weediness, resistance, and profits?

Factors to consider when adopting weeding robots:

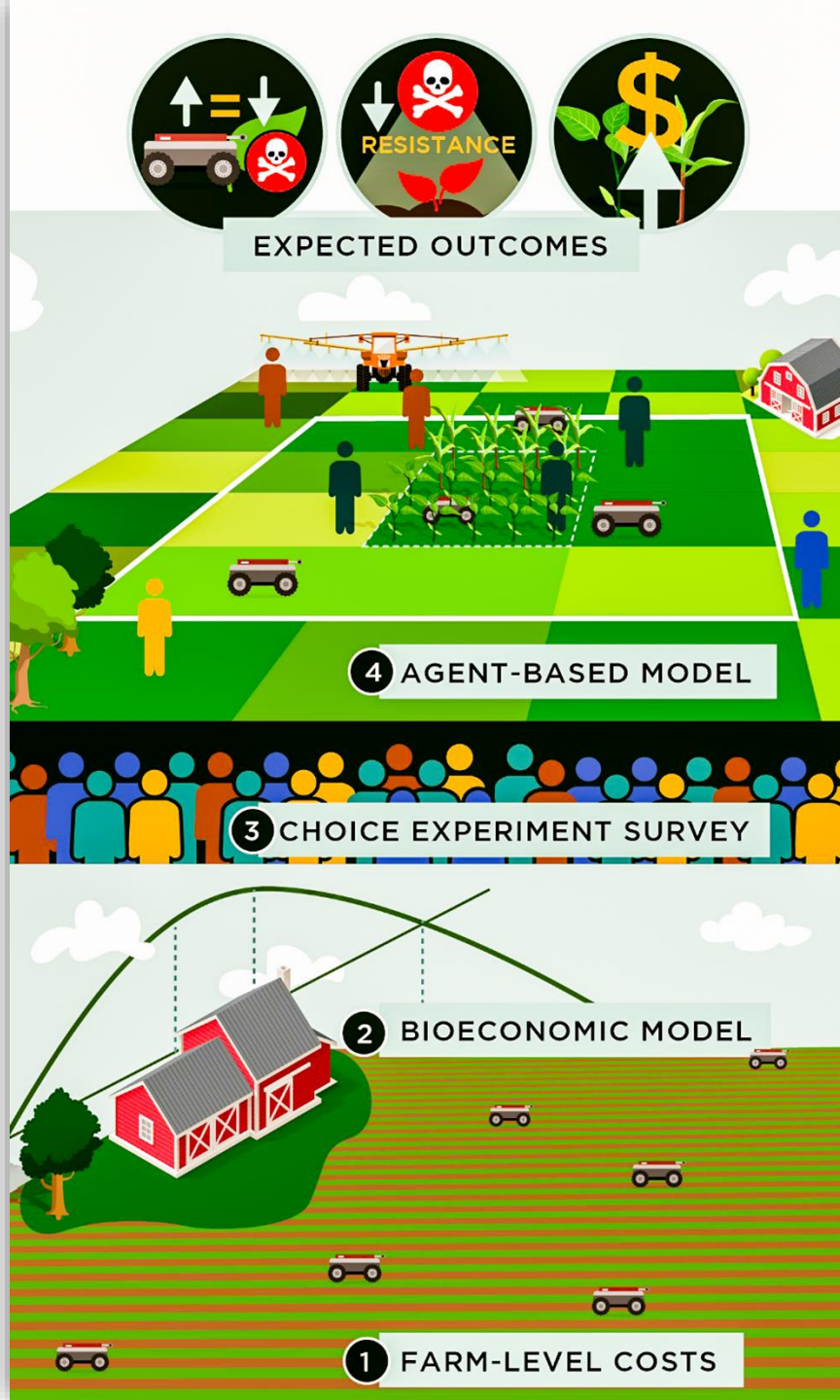
Weed management ‘type’

- Myopic weed management
  Does not / cannot take weed and resistance dynamics into consideration

- Forward-looking weed management considers these dynamics

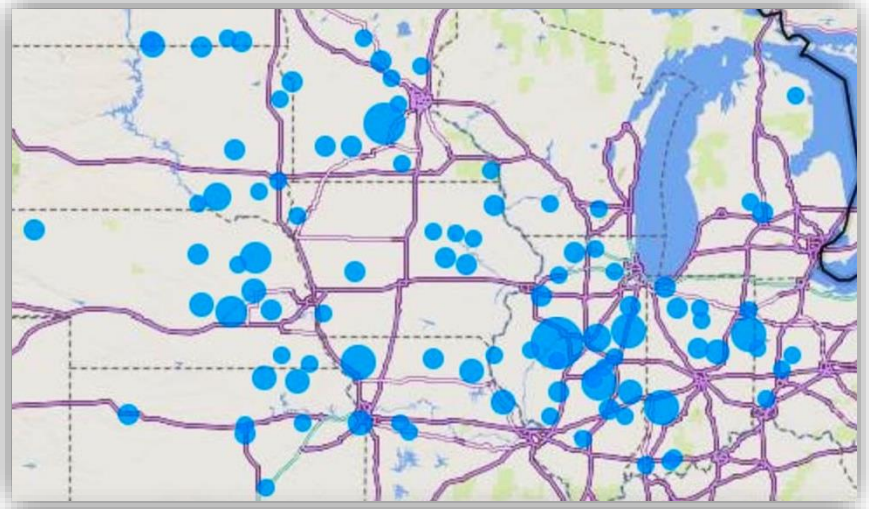
The questions we asked

- Will corn farmers adopt weeding robots?
- What conditions would trigger weeding robot adoption (weed count and resistance, robotic technology, and robot price)?
- How can robots be optimally used (intensity and timing, relative to herbicides)?
- How would their adoption affect profits and weed resistance development?



1. Will corn farmers adopt weeding robots?

Choice experiment survey of 251 farmers (12 states)



More than half said they would!

1. Will corn farmers adopt weeding robots?

Farmer respondents are *more* willing to adopt robotic weed management if

- Robots have higher effectiveness at reducing weeds
- They face greater weed resistance

1. Will corn farmers adopt weeding robots?

Farmer respondents are *less* willing to adopt robotic weed management if

- Neighbors have fields with high weed counts

Farmers are not concerned with:

- the number of passes needed

1. Will corn farmers adopt weeding robots?

Farmers are willing to pay

- $25 per acre for a 1 percentage point increase in the proportion of their crops affected by herbicide-resistant weeds.
- $23 per acre for a 1 percentage point decrease in the percentage of neighbors with high weed counts.
- $220 per acre for a 1 percentage point increase in the effectiveness of the robotic technology.

2. How would farmers adopt weeding robots?

Not a yes/no adoption decision;

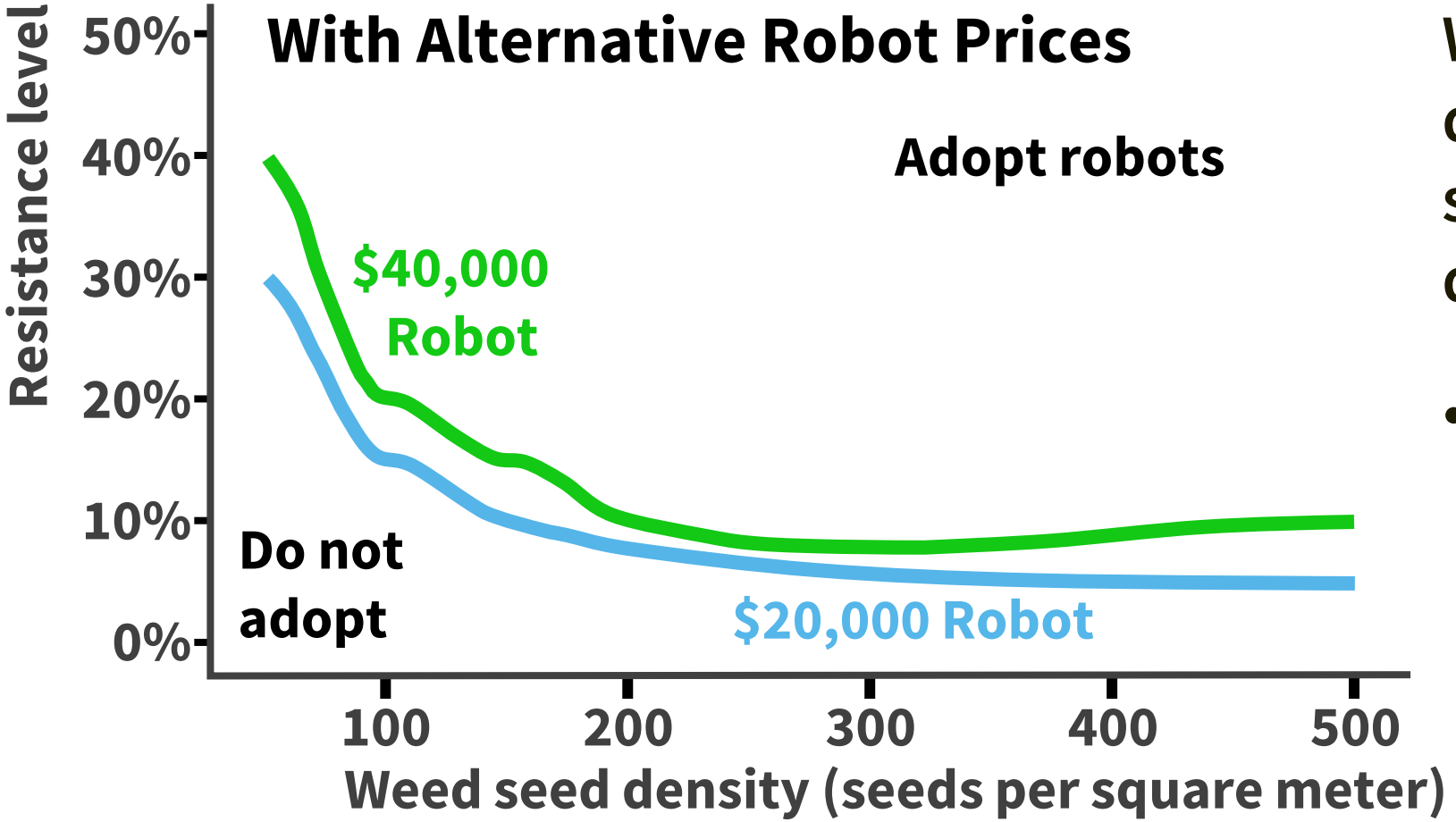
- When should robots be adopted?
- What share of the land is to be weeded by robots vs. herbicides?
- At what threshold of weed resistance and density, is it optimal to switch from herbicides to robots?

2. How would farmers adopt weeding robots?

Needs a model integrating

- Farm economics
- Weed ecological dynamics
- Robotics

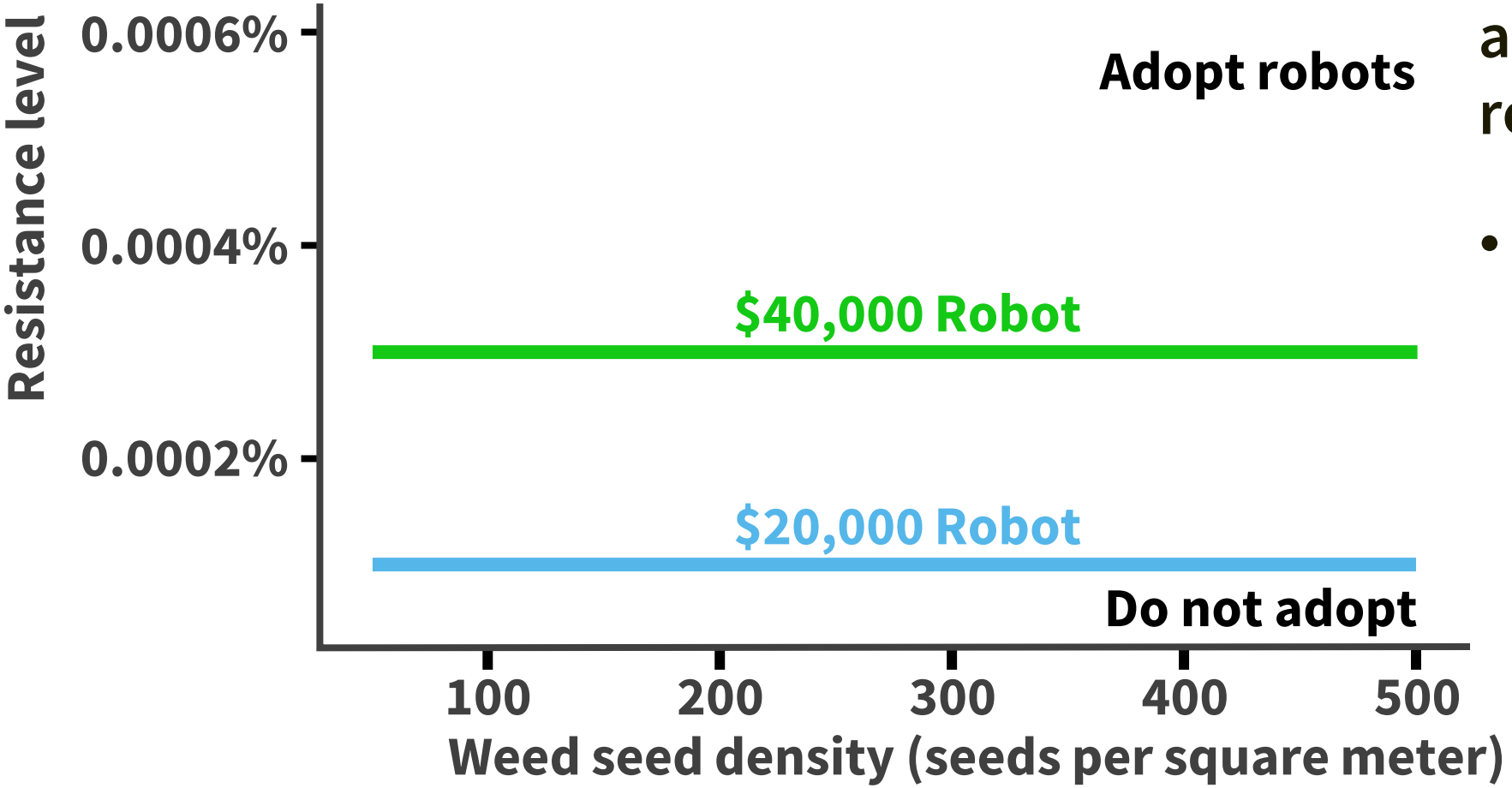
2. What conditions would trigger weeding robot adoption?



Weed management that does not account for seed and resistance dynamics:

- Adoption occurs as weed density increases and/or as resistance increases.

2. What conditions would trigger weeding robot adoption?

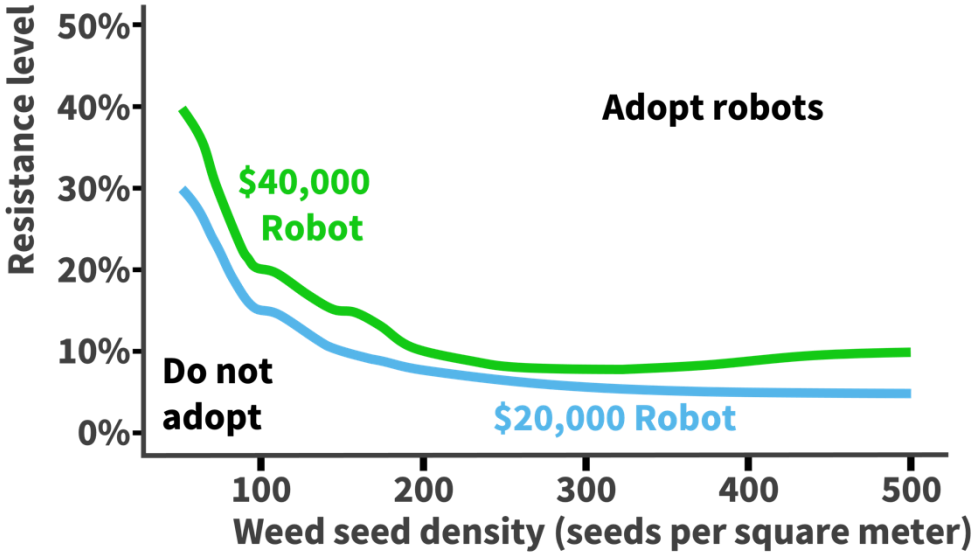


Weed management that accounts for seed and resistance dynamics:

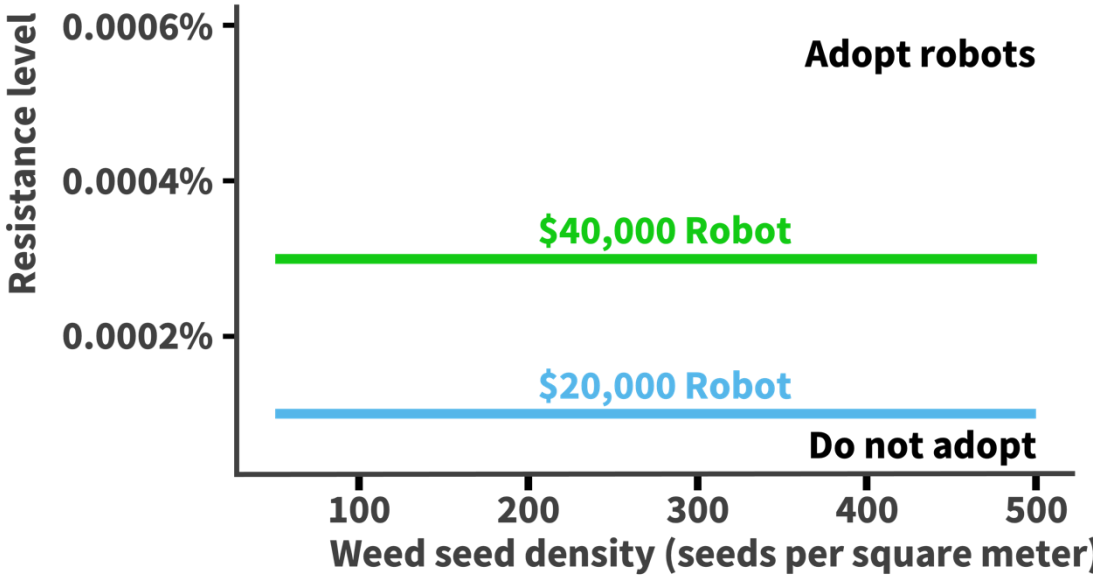
- Adoption occurs as resistance increases, regardless of weed density.

Threshold resistance and weed density levels that would trigger the adoption of weeding robots under myopic vs. forward-looking weed management

Myopic = does not account for seed and resistance dynamics



Forward-looking = accounts for seed and resistance dynamics.

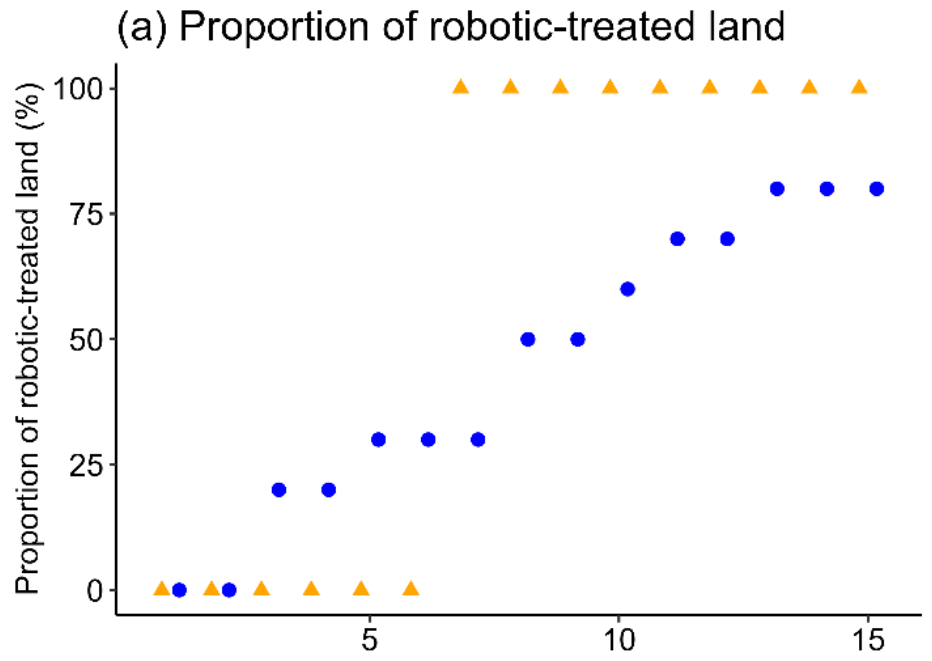


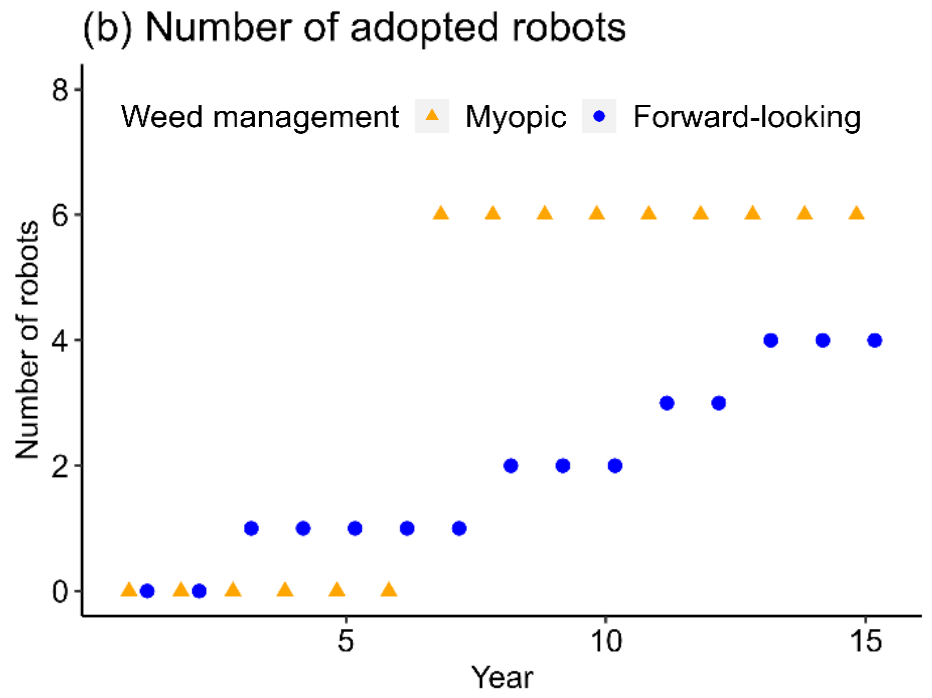
- Under forward-looking management, adoption occurs for much lower resistance levels, compared to myopic weed management.
- Initial weed seed density
  - matters for myopic weed management
  - has little impact on forward-looking weed management.

3. How would robots be optimally adopted?

Forward-looking weed management (blue dots) leads to adopting:

- Robots earlier
- Fewer robots
- Treat fewer acres
  - Treat robots and herbicides as complements and not substitutes



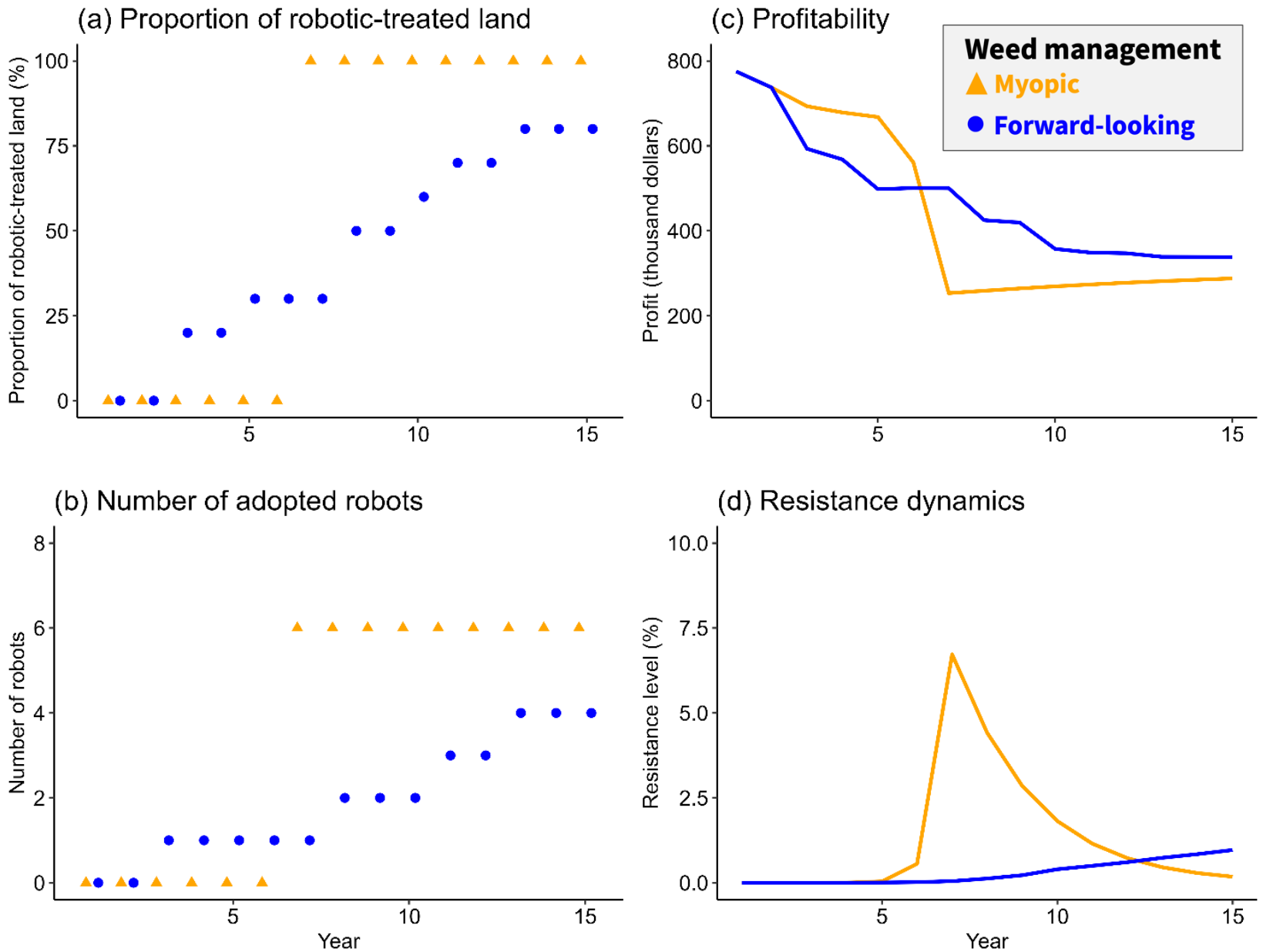


Weed management
▲ Myopic
● Forward-looking

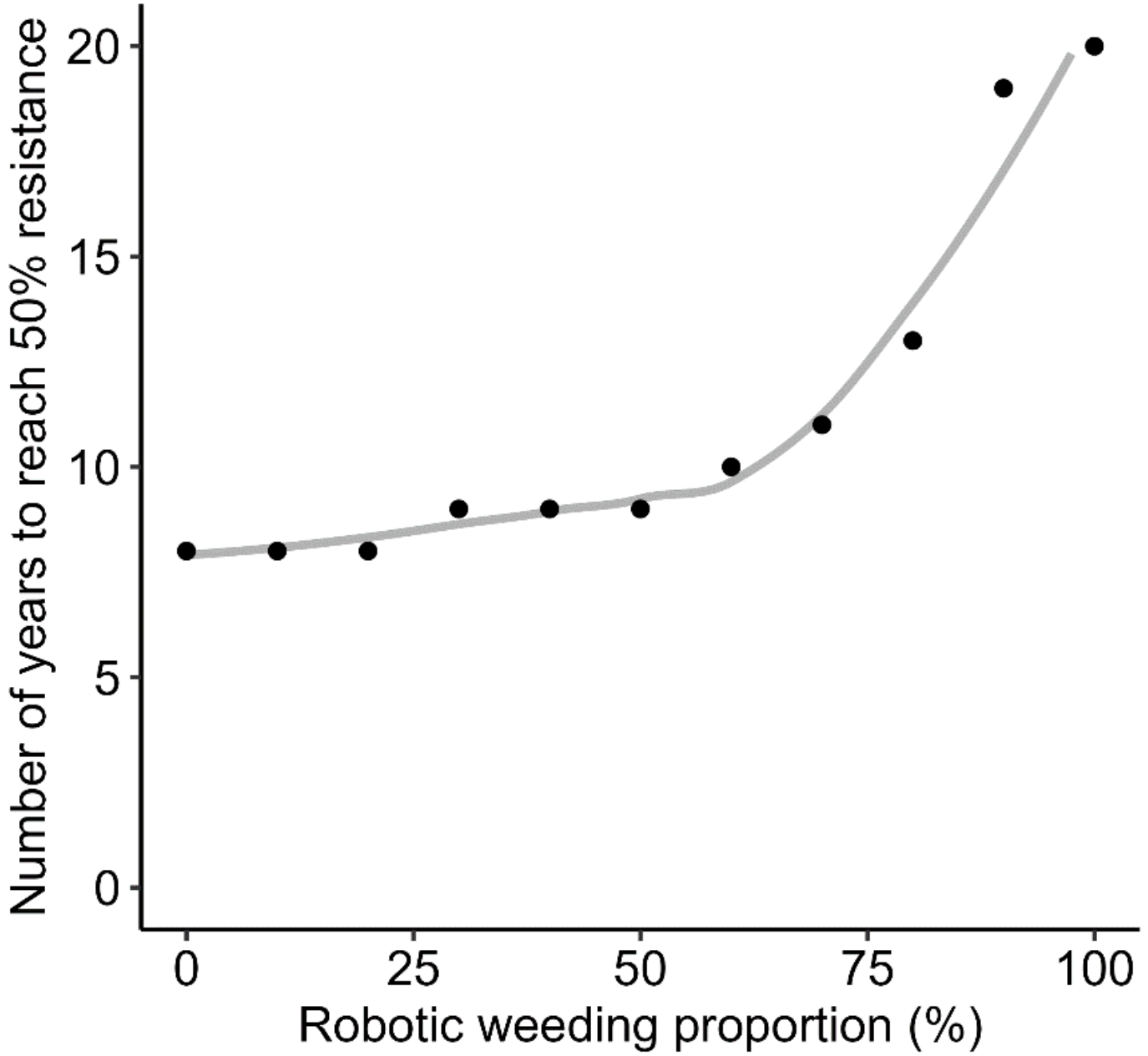
4. How does adoption affect profits and resistance?

Forward-looking weed management leads to adopting:

- Achieve higher profits
- Lower resistance in most years
- But may lead to higher resistance in the long run than myopic management



How can robots use intensity delay resistance?



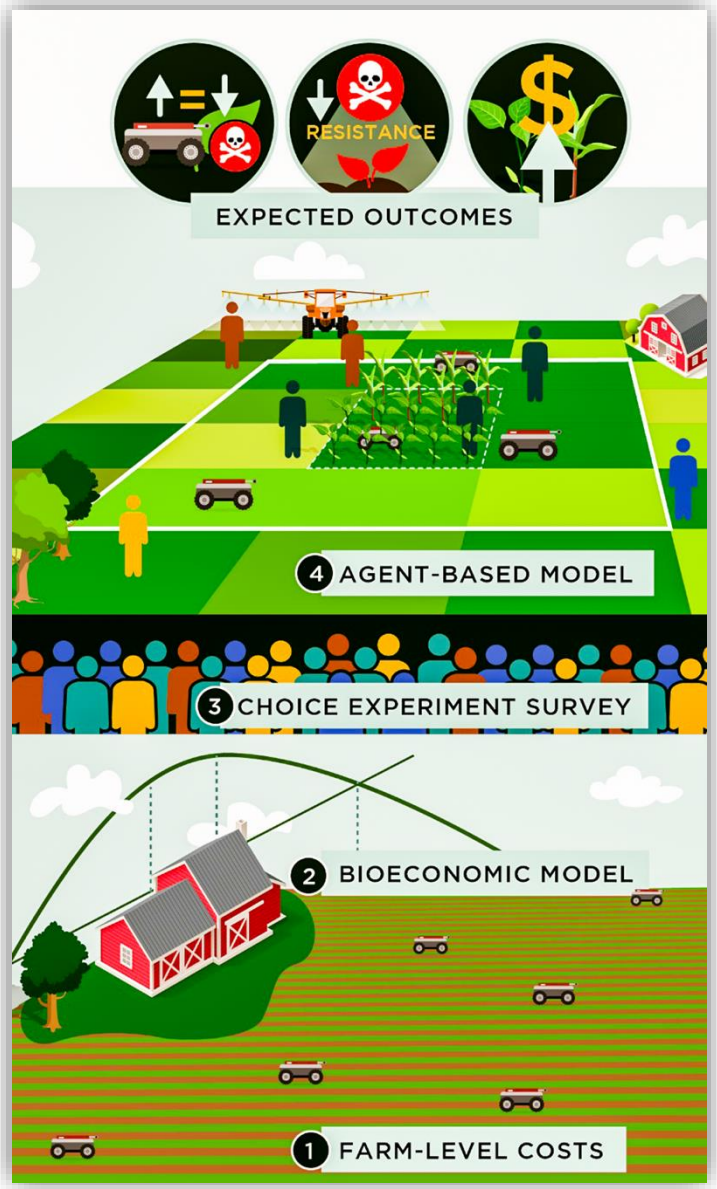
The questions and answers

Will corn farmers adopt weeding robots?

More than half said they would!

What conditions would trigger weeding robot adoption?

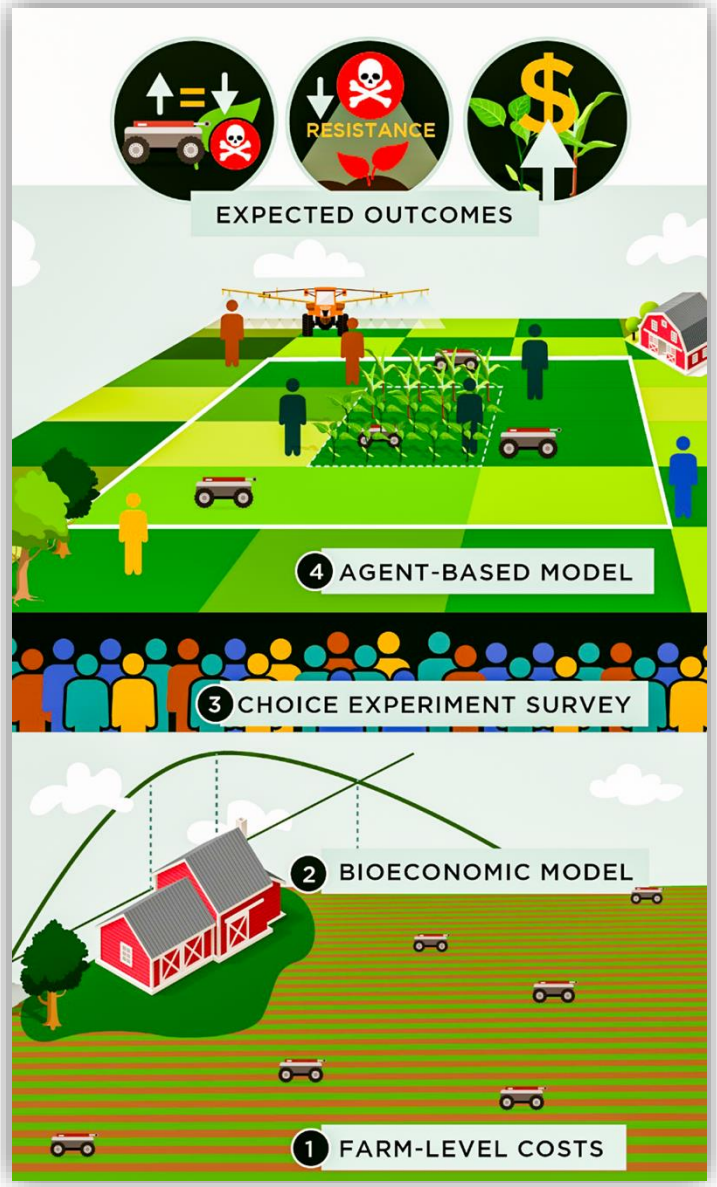
Resistance level



The questions and answers

How would robots be optimally adopted? (intensity and timing, relative to herbicides)?

Forward-looking management: adopt earlier and fewer, use them as complements to herbicides.

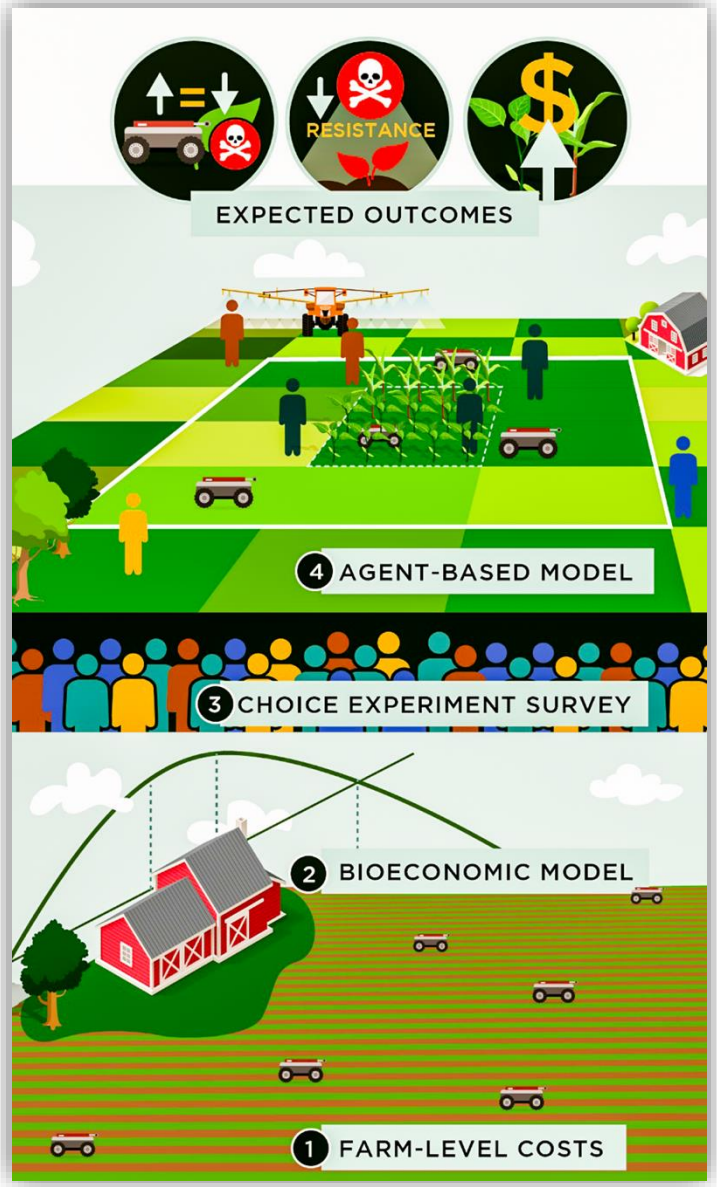


The questions and answers

How would their adoption affect profits and weed resistance development?

Forward-looking management leads to:

- Higher profits
- Lower resistance



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Herbicide-resistant weed management with robots: A weed ecological–economic model

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Abstract

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National Institute of Food and Agriculture

Farmer respondents needed for a nutrient management survey

- Survey to provide economically optimal application recommendations for Phosphorus (P) and Potassium (K) fertilizers
- To increase farmers' profits and promote environmental sustainability
- Based on a maximum return to P or K (MRTP or MRTK) and account for P fertilizer price or K fertilizer price, corn or soybean prices, and effect of P or K levels on yield.

Farmer respondents needed for a nutrient management survey

We want to investigate:

- **Farmer preferences for potential changes resulting from adopting P and K recommended fertilizer application rates;**
- **Incentives needed to induce the adoption of these tools.**

20 out of the first 1,000 survey participants will receive a $100 gift card each.

https://go.illinois.edu/NutrientManagement-extension

Thanks!

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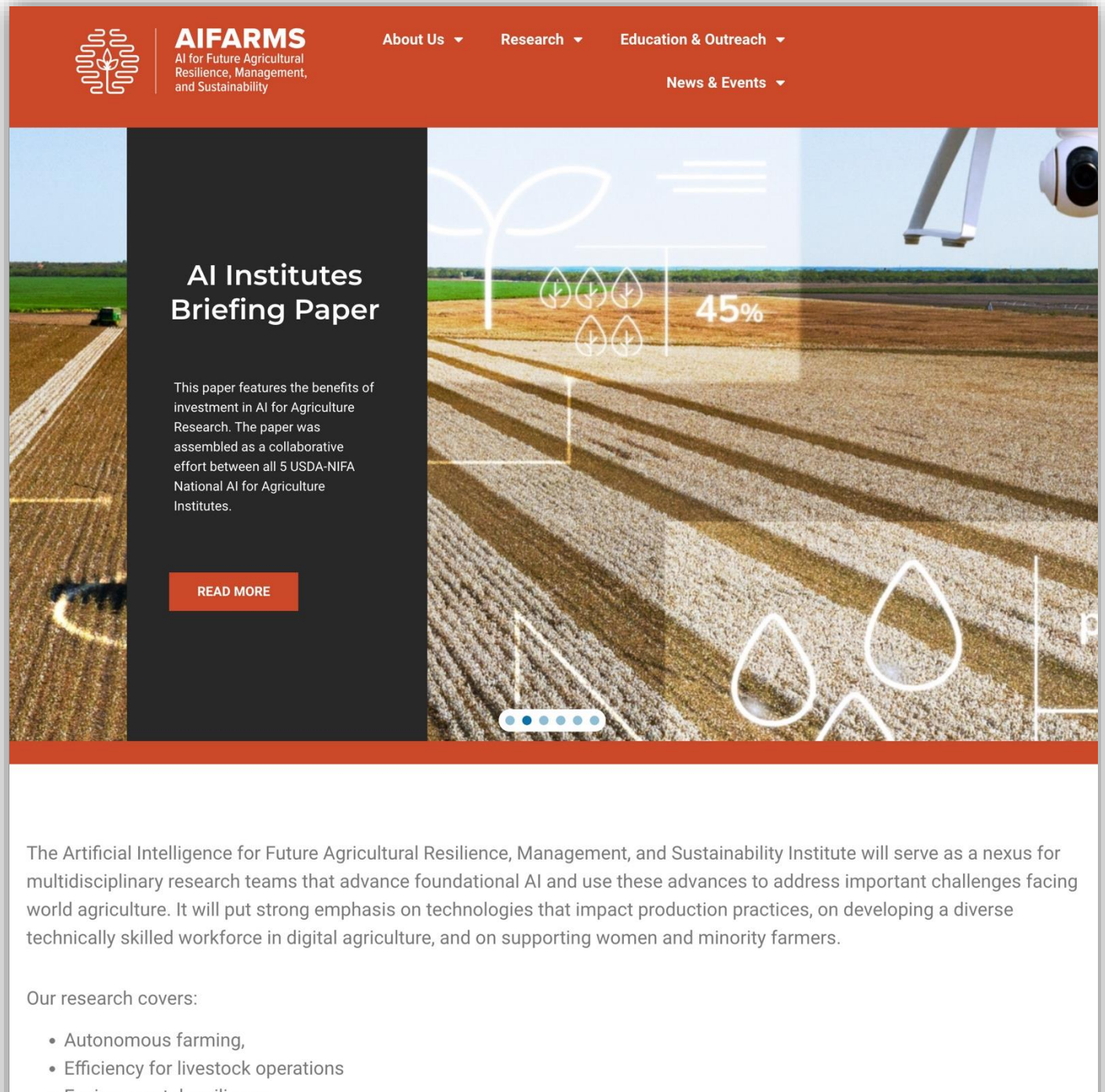

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I-FARM stands for "Illinois Farming and Regenerative Management." This University of Illinois-led study — funded for three years and $3.9M by the U.S. Department of Agriculture's National Institute of Food and Agriculture (NIFA) — is developing an 80-acre agricultural testbed, where commodity crops, cover crops, and livestock are farmed using synergistic, sustainable practices.

The I-FARM testbed features improved precision farming with remote sensing; new autonomous solutions for cover-crop planting, variable-rate input applications, and mechanical weeding; and artificial intelligence-enabled remote sensing for animal health prediction, nutrient quantification, and soil health.

Videos from the field

A full I-FARM video playlist may be found on YouTube >>>

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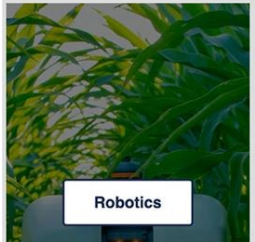

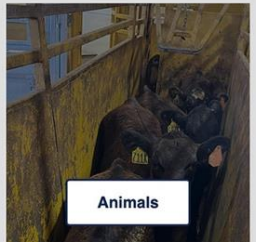

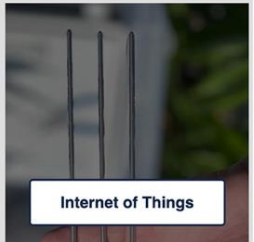

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